DOCUMENT RESUME

ED 118 397 SE 020 211

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TITLE A Case Study in Multidisciplinary Engineering Education: Urban Systems Engineering.
PUB DATE Jun 75
NOTE 27p.; Paper presented at the Annual Meeting of the American Society for Engineering Education (Colorado State University, Ft. Collins, Colorado, June 16-19, 1975); Marginal legibility in appendices

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage
DESCRIPTORS *City Problems; *Engineering Education; Graduate Study; Higher Education; *Interdisciplinary Approach; Internship Programs; *Masters Degrees; *Program Descriptions; Universities; Urban Areas; Utilities

ABSTRACT

A discussion of a multidisciplinary graduate degree program is presented. The Urban Systems Engineering Program is analyzed in terms of curriculum, the role of internship, faculty, and of evaluations which have been made. Appendices include entrance and degree requirements, a listing of student electives, and an annotated required course listing. (CP)

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EVENT NUMBER 2655

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ANNUAL CONFERENCE, JUNE 16-19, 1975

COLORADO STATE UNIVERSITY

FORT COLLINS, COLORADO 80521

TITLE OF PAPER "A CASE STUDY IN MULTIDISCIPLINARY ENGINEERING EDUCATION: URBAN SYSTEMS ENGINEERING"

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SE020 211

PRESENTED AT THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION CONFERENCE
FORT COLLINS, COLORADO
JUNE 17, 1975

A CASE STUDY IN MULTIDISCIPLINARY ENGINEERING EDUCATION: URBAN SYSTEMS ENGINEERING

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ABSTRACT

A discussion of a new multidisciplinary engineering-based curriculum is presented. Emphasis is placed on the innovative aspects of the staff and students. Some problems of graduate socio-technical systems curriculum design for non-engineers are discussed.

I. Introduction

In this paper, I will review some of our experiences with a new graduate multidisciplinary engineering curriculum which is designed to prepare students for careers in the public sector. The program which will be discussed is now in its third year at Howard University's School of Engineering.

Howard, founded more than a hundred years ago, presently has an enrollment of more than 9,000 students students. The University has seventeen colleges and schools which offer a full complement of degrees from the baccalaureate through the doctoral level. Located in the large urban center of the District of Columbia, Howard's student population is predominantly Black and the University traditionally has had one of the largest gatherings of Black scholars, many of whom have gained international prominence.

With the presence of these factors which were very congenial to its purpose, the School of Engineering, with the aid of a grant from the Alfred P. Sloan Foundation, embarked in the fall of 1972 upon an innovative path to establish a new type of graduate engineering professional education. This educational thrust was embodied in the Urb stems Engineering Program. I would like to first discuss U.S.E. program in relation to the total curriculum of the School of Engineering.

II. Organizational Structure

The School of Engineering, which has a total enrollment of 568 students, of which 65 are graduate students, is structured along traditional lines. The school is organized into four departments -- chemical, civil, electrical, and mechanical through which all undergraduate degrees are offered. A joint program exists between the School of Engineering and the School of Business and Public Administration which allows a student to work towards a BS/MBA. Within departments, undergraduates may specialize in several areas through the election of special options in their undergraduate programs. For example, Civil engineering offers a structures' option; Electrical, an antennas and computer option, and Mechanical, a nuclear option.

The "traditional" graduate degrees, although administered by the engineering departments, are awarded by the University's Graduate School. Presently, there are programs which offer the Master of Engineering in Civil, Electrical and Mechanical and the Master of Science in Computer Science.

With the establishment of the Urban Systems Engineering Program, a new organizational model for graduate engineering education was introduced at Howard. The emphasis of the U.S.E. Program is on

professional education as opposed, let us say, to research, and therefore the organizational model employed was that found at many of the nation's schools of business administration, i.e., the U.S.E. Program be administered by the Director of the Program and the graduate degree would be awarded by the School of Engineering. Part of the rationale for this structure was that the objectives of the program (which will be presented later), could best be achieved through an organization which focused control at the relevant professional school.

We now look at the U.S.E. Program.

III. Urban Systems Engineering at Howard University

The U.S.E. Program was designed as a problem-oriented master's program for students who possessed undergraduate degrees in quantitative areas, e.g., engineering, physics, etc., and who desired careers in the public sector, or in the private sector with companies and institutions dealing with public problems. The program was conceived to prepare students for professional-level entry positions as managers, engineers, and analysts, as opposed to being a waystation for law school, medical school or a Ph.D. pursuits. The objectives of the program

are to

(1) train people who possess quantitative and technical skills in the systems approach to problem solving;

(2) provide students an opportunity to apply their talents to the urgent urban systems problems facing the nation;

(3) develop a successful program design to serve as a model for universities throughout the nation in order to help focus the scientific and technical capabilities of the nation on urban problems;

(4) provide a variety of educational opportunities for full-time and part-time students, faculty members, people in the public sector, and others through a formal master's degree program, seminars, and a series of short courses;

(5) develop a cadre of active urban researchers with a nationally recognized competence in urban research at Howard.

I will comment on the degree to which we have been successful in meeting these objectives in my discussion of the assessment of the U.S.E. Program.

A two-year interdisciplinary systems engineering curriculum was selected as the most feasible educational vehicle for meeting these objectives. The length of the program and its emphasis on problem solving imparted a professional quality to the Master

of Urban Systems Engineering in contrast to the typical engineering master's degree. We now look at the structure of this curriculum. (For detailed review of the curriculum the reader is referred to the appendix).

IV. Curriculum Structure of U.S.E.

The U.S.E. master's degree program is a two-year 48 credit-hour curriculum; in addition students are required to complete an internship during the summer months between their first and second year. The curriculum is systems engineering based with a heavy inclusion of social sciences and public administration courses. The curriculum hours are distributed as follows:

A.	Systems Engineering and Operations Research	12 hours
B.	Statistics, Mathematics, Modeling & Simulation	12 hours
C.	Social Sciences and Administration	12 hours
D.	Urban Research Seminar	6 hours
E.	Electives	6 hours

Courses in categories A, B, and D are offered within the School of Engineering. The courses in category C are generally offered by other units of the University outside the School of Engineering; however, during the past year engineering developed a course in econometrics designed around urban problems.

Non-traditional Engineering Courses

In this program, we experimented with using the community as a

learning laboratory. This was done in the urban research seminar, a course taken by students in the second year after having been exposed to the methodology and techniques of systems engineering and operations research.* The objective of this course is to give the student an opportunity to become involved in urban problem solving. It was our intention that the students gain such experience from the perspective of the citizen, thereby increasing their sensitivity and awareness of the real world. We felt there would be ample opportunity for students to look at problems from a bureaucratic perspective during their professional careers. With this in mind, we contacted local community action-oriented organizations and invited them to participate in our program. The first year we offered the seminar, we obtained the cooperation of a local Community Action Program (CAP) which is sponsored by the Office of Economic Opportunity (OEO). This local agency is a general social service citizen advocacy organization for a relatively small neighborhood in the Northeast section of Washington, D.C. The neighborhood selected has all the typical problems one associated with large urban centers. The seminar began with a

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* This seminar consists of two course sequence over a one-year period and yields six credit hours.

presentation by the staff of the CAP agency of what they viewed as their critical urban problems and how we might assist them. After several visits to the agency and some discussion, it was decided that the most effective way for U.S.E. to participate in the program would be for the students to work on the various task forces of the agency. The agency had already organized committees around areas which were viewed as the critical issues in the community, i.e., housing, transportation, health services, and economic development. A plan was developed for our students to work as 2-person teams in each of these areas and to help prepare an assessment of the state of the community in each area. It was necessary for the students to attend the community meetings, agency policy board meetings, and their own committee meetings to get a "feel" for what was going on in each problem area.

The only academic requirements in the first semester was a paper from each student team which was to essentially "define the problem" in their specific area, e.g., "what is the housing problem in this section of Washington?" These papers were used as the groundwork for action proposals from the community to be presented to responsible agencies in the District bureaucracy. Generally, these papers were very thorough and contained an enormous amount of research about the city in general and the

neighborhood in particular.

In the second semester the students continued to work in the same problem area; and paper was also the only academic requirement in this semester. However, the second paper was to be prescriptive as opposed to descriptive, i.e., "what are the options available and what are the consequences in a problem area; what are other cities doing, etc."

This format has been followed for the two years that the urban seminar has been in operation. However, the second year the seminar was given in conjunction with an urban planning course in the Urban Studies Program (another unit in the University). In this case, the student teams consisted of the quantitatively-oriented U.S.E. types and the social science oriented urban studies students.

This was an interesting experiment for both the U.S.E. students and the staff, since the class truly was interdisciplinary and discussions of our approaches to problem solving showed the differences in backgrounds. As in the first year, the class acted as "expert" consultants to a community action group. The overall project consisted of several tasks in the community problem areas, e.g. health services and housing. When the students divided the

tasks among themselves, an interesting dichotomy occurred. The engineering students opted for the more quantitati[illegible]sks, i.e., technician roles; whereas the urban studies students were involved in the policy-type functions. (We hope this is not always the case in the real world!) We did not achieve the expected interactions on a working level between students with different backgrounds.

In assessing our experiences in the seminars, we are somewhat equivocal about the format described above. On the one hand, we feel (and so did the students) that the idea of working on a "real" urban problem as defined by the community adds perspective and is a useful part of the student's academic experience. The students felt that their introduction and training in systems methodology allowed them to take a somewhat nebulous problem, e.g., housing, and at least develop a systematic framework for analysis and discussion. However, some students questioned the relevance of some of the more traditional elements of our curriculum, e.g., operations research techniques (linear programming). In critiquing the seminar with the students we were able to address this by, pointing out, for example, the various levels (prespectives) one could be working on when dealing with an urban problem. A major problem with the format of the seminar is the tremendous amount of time required not only

by the U.S.E. staff, but especially by the student. Attending community meetings, working with community committees, visiting city agencies, etc; can be a tremendous burden on a student who is carrying a full-time graduate load.

Another problem experienced is that of delineating the role of the student in such a venture. The agency or community group must clearly understand the exact scope of the duties and tasks of the students; otherwise students can become involved in activities which are best carried out by the agency staff or volunteers.

In the first year, the U.S.E. Program requires a two-semester sequence in urban systems engineering. The first semester course is a course in systems methodology and process, while the second semester deals with case studies in urban systems engineering. In the case studies course, the objective is to get the student involved in the study of some specific urban subsystem. The course has been designed around the problem of creating a new, viable city located at a distance from existing urban centers. Demographic and physical constraints are specified for the "new city" and each student is required to participate in the planning and development of the city. Each student acts as the expert on a particular city subsystem. The academic requirements for this course include two oral presentations by each student

and a written report. In the final presentation, which is semi-public, we have had various city administrators as guests, and each student presents and defends his or her solution or plans for the subsystem proposed.

During two-semester sequence in urban systems engineering, the student is given an idea of what this new discipline of urban systems engineering entails. In the latter part of the course on systems methodology, a case study is reviewed to show examples of the urban systems engineering process in action. In designing a new city, the student is presented an opportunity to participate first hand in the urban systems engineering process. We feel these two courses have been relatively successful in achieving their goals.

One problem which we had anticipated was the variety of backgrounds of the students. We have had students graduate from our program whose undergraduate degrees were in engineering, mathematics, and economics. In the two urban systems engineering courses we tried to establish a threshold of understanding and competence in systems terminology and methodology below which no student would fall regardless of his background. Since this course dealt with methodology, as opposed to techniques, which is to say common sense, the social science (economics) trained

students did not appear to be at any particular disadvantage. In courses dealing with operations research techniques and modeling, it did appear that the mathematics and engineering trained students were better prepared because of their backgrounds. In discussing this problem with the students they were quick to point out that the reverse situation existed in some of the social science courses, e.g., public finance. We do not presently see a resolution of this problem. What we have done to ameliorate this problem, is to offer, on an informal basis, refresher lectures to bring some of the less quantitatively oriented students up to speed. We feel there is something to be gained by having economists and other nonengineering types in the program since they tend to bring a certain perspective to urban problem solving that sometimes is lacking in the engineers.

Role of Internship

The summer internship is viewed as a major opportunity to give the student professional experience before completion of the academic program. These experiences make the student more attractive to prospective employers. In the three summers (including 1975) that we have placed students in internships, they have been employed at agencies such as the National Bureau of Standards, the District of Columbia's Environmental Services Department,

the Rand Corporation, the Mitre Corporation, the Department of Public Works in Baltimore, and the Federal Department of Transportation. The first two summers of the program, employers paid the students during the internship. For the summer of '75, some students are being sponsored through a stipend by the Urban Environmental Intern Program. These stipends for the summer interns were made possible by a grant from the Rockefeller Foundation. We have found, however, that when we are able to secure outside funds for the internships, we are more likely to secure the kind of on-the-job experiences which are consistent with the educational goals of the individual students.

On balance, we feel that the internship is a valuable part of the educational program. However, the major problem we have experienced with internships in tight economic circumstances, is the difficulty of securing the type of position that will contribute to the student's professional growth. Careful planning is necessary to achieve this important goal.

5. Assessment of Program Experiences

In May '75, we had our second set of graduates from the program.

This brings the total number of graduates to ten. In assessing our program in terms of the activities of our graduates we have the following observations: Even though we did not view this program as designed primarily as preparation for a Ph.D. program, we feel that, if after a student has completed the requirements and should the student opt for this alternative, the program should be at the necessary academic level to allow the student to proceed at least at the rate of students coming out of traditional operations research and related masters' programs. To date, three students have gone directly from our program into Ph.D. programs at other universities--two students are in Ph.D. programs in urban systems engineering and one is pursuing a Ph.D. in operations research. The remaining seven students left our program and joined the work force. Four students are employed by federal and local agencies as analysts; two students are working for private companies dealing with large-scale public; and one student joined a university research staff.

With regard to the original objectives, we can say that we are meeting them to some degree. So far, our output has been five students per year trained in the systems approach to urban problem solving. We intend to attempt to raise this over the next few years as we find the types of students willing and prepared

for the rigorous approach to urban problems.

In our program we have provided the student with opportunities during their academic careers to apply their training to urban problems.

The success of our program design is hard to evaluate at this particular point in time. However, since the inception of our program in the fall of 1972, we have noted the initiation of similar types of programs at a number of other universities. This seems to indicate that others feel this might be an appropriate direction in one aspect of engineering education.

As yet, we have not attained the variety of activity envisioned in the original conception of the program. For example, we have not been able to provide the number of special courses and seminars which would be useful for professionals not interested in a formal degree program. This aspect of program activity is constrained by available resources.

We have research projects in emergency service systems, and transportation. Also the degree of our success in developing a cadre of active urban researchers with a nationally recognized competence in urban research is not measurable at the moment. We feel we are moving in the correct direction to be successful

in achieving this goal.

One area of relative success has been in establishing a working relationship with the local governments in the immediate area. We have had managers from local governments participate in our seminars and have had local governmental agencies assist us in defining urban research problems. Local agencies have been helpful in hiring our program students and using our interns. They have also assisted us by providing real data from their operating agencies for our urban research problems. We hope to continue and expand our interactions with local governments.

VI. Faculty of the U.S.E. Program

The faculty of the U.S.E. Program currently consists of four people. This includes a full-time director and one full-time operations research specialist. We also have one faculty member with a joint appointment in U.S.E. and the Civil Engineering Department, and a professor from the Graduate School of the University who serves one-quarter time.

Periodically, we have had specialists from government and local companies teach courses in the areas of systems engineering, operations research, and economic processes.

The research interest and areas of specialization of the faculty include:

Emergency Ambulance Systems
Public Transportation Systems
Solid Waste and Collection
Building Systems
Computer Systems and Operations Research

VII. Conclusion

In summary, I would like to indicate the future directions and goals for the U.S.E. program at Howard University. An immediate future objective is to raise the number of graduates to about ten per year from its present level of five. Academically, we would like to better integrate the economic sequences with the remainder of the curriculum. In that regard we are looking for an economist to work closely with the engineering staff.

An important asset would be the establishment of an Urban Systems Research Laboratory which we are currently planning. The function of such a laboratory would be to provide a framework for a variety of long term interdisciplinary research projects, training projects, and special activities.

Finally we have a job to do outside the university in spite of the success we have had with some local governments. We have to sell some metropolitan governmental officials on the

utility of a systematic approach to the planning, management, and operation of public service systems. In the long run, we feel that the operating agencies of metropolitan governments will be the primary employers of our graduates.

APPENDICES

CURRICULUM
URBAN SYSTEMS ENGINEERING

MASTERS OF URBAN SYSTEMS ENGINEERING

The Masters of Urban Systems Engineering is a two-year professional degree program offered within the School of Engineering. The degree program is designed to provide the student with three types of learning experiences:

(a) Technical and social scientific skills through formal course work,

(b) Practical experience through internships and case studies,

(c) Research.

REQUIREMENTS FOR THE DEGREE: The program requires two full years of study. A total of (36) semester hours of academic work, (12) semester hours of case studies and research, and a three month summer internship working in urban systems is required.

ENTRANCE REQUIREMENTS: Applicants to the program will be expected to have undergraduate backgrounds consistent with the requirements for entrance to Howard University's Graduate School. Undergraduate training in the quantitative sciences is necessary with the engineering, mathematics, and physical sciences preferred.

ACADEMIC REQUIREMENTS:

A cumulative grade of 3.00 (B) is required for graduation. A student who accumulates more than 15 credits below a B will be dropped from the program. A student who drops below the 3.00 average will be warned and placed on probation. He will be informed that he must raise his quality point index to 3.00 in the next two semesters in residence. If the student fails to do this he will be dropped from the program.

An outline of the curriculum for the Urban Systems educational program follows.

1st Semester

238-500. Introduction to Urban Systems Engineering 3 Credits

Concepts of systems engineering methodology; systems studies, program planning, project design and implementation; problem definition, value system design, systems synthesis, analysis and selection. CPM and PERT. Application to urban systems; case studies around such topics as processes and structures of transportation systems, water quality control, emergency service systems or health care delivery systems.

238-510. Computer Simulation and Modeling 3 Credits

Simulation and modeling applications of computers to urban systems problems. Topics include modeling, usage and construction of simulation languages. The course presumes a knowledge of Fortran.

238-520. Statistical Techniques I: Basic Statistics 3 Credits

Foundation of probability theory, statistics, introductions to conbinatorial analysis, concepts of density and distribution function, measures of central tendencies and dispersion.

233-550. Operations Research and Systems Engineering I 3 Credits

Techniques of systems analysis through linear programming and its network extensions. Linear programming concepts and functions, linear, algebra, geometry of linear programs, simplex procedure, dual problems. Network problems; transportation, assignment, transhipment, shortest path and critical path problems. Application to urban systems problems are stressed throughout.

2nd Semester

238-530. Economic Processes I: Urban Economics (See Economics 196) 3 Credits

Methods of private and public finance, cost/benefit analysis of urban services; economics of urban renewal, suburbanization of employment, and population and race problems in urban areas.

238-521. Statistical Techniques II: Sample Survey Techniques. 3 Credits

Introduction to sample survey techniques, topics covered include simple random sampling, techniques for sample selection, stratified sampling, cluster sampling, ratio estimates. Course also includes basic curve fitting using multiple and linear regression.

238-501. Case Studies II. Urban Systems Engineering 3 Credits

Topics to be selected by instructor, more emphasis on the social-technical systems as opposed to physical-technical systems as in Case Study I.

238-650. Operations Research and Systems Engineering II 3 Credits

Mathematical programming; dynamic and non-linear programming, queuing theory, Markov modeling. Application to urban systems problems are stressed throughout.

238-001. Summer Internship Zero Credits

The student is required to spend at least 10 weeks, preferably during the summer months, working full time in a public or private agency, or a city, state, or national government. The student must work in a capacity which broadens his professional skills as an Urban systems engineer. The position must be approved by the program and a written report is required at the end of the internship. This course is taken under pass/fail option.

3rd Semester

238-541. Socio-Political Processes I: Administrative Processes (Urban Administration 131-481) 3 Credits

Municipal budgeting and revenue systems, resource allocation PPBS, government sector economics, administrative problems of organization.

238-600. Research (Taken under pass/fail option) 3 Credits

Groups of students participate in research projects supervised by the faculty of the Urban Systems Program. Such projects are designed to replace the Master's Thesis normally associated with the graduate degree.

238-630. Econometrics II: Econometrics — 3 Credits

The application of mathematical form and statistical techniques to the testing and quantifying of economic theories and the solution of economic problems.

Elective — 3 Credits

4th Semester

238-640. Socio-Political Processes II — 3 Credits

(See Urban Government 131-480)

Urbanization and growth of cities development structure, theory, functions, and politics of modern municipalities; administrative organizations and processes.

238-610. Analysis of Urban Service Systems. — 3 Credits

Advanced methods of systems analysis, including some special problems in probability, queuing and networks. Application to urban problems is stressed throughout.

238-601. Research (Taken under pass/fail option) — 3 Credits

Electives — 3 Credits

SUGGESTED ELECTIVES

Economics

254 Economic Development
275 Comparative Economics

Mathematics

180 Linear Algebra and Matrix Theory
189 Mathematical Statistics I
190 Mathematical Statistics I

City Planning

640 Transportation Concepts

Urban Systems Engineering

238-655 Mathematical Programming

Government

188 Pol. Prospects of Blacks
185 Political Behavior
215 Administrative Processes

Engineering

EE 555 Random Processes
501-502 Ad. Eng. Analysis
CE 543 Radioisotope Engineering
502 Waterwaste Treatment
505 Industrial Wastewater Management
531 Environmental and Health Engineering
550 Water Quality Management
511 Chemistry of Water and Wastewater
577 Urban Transportation Planning Models
578 Transportation Systems Analysis
579 Urban Transportation Planning
580 Traffic Engineering

African Studies

230-270 Urbanism in Africa

Medicine

Community Health Practices

Law

Ecological Jurisprudence